Background

Looking at a map of Denmark you will see that the country consists of one peninsula, Jutland, and a multitude of islands, the largest of which are Fyen (Funen), Sjælland (Zealand), Falster and Lolland.

International traffic follows two main lines, one coming from North Germany through Slesvig to the town of Fredericia where it divides into two lines, one continuing north to the main towns of Jutland (Aarhus and Aalborg), and the other going east across the islands of Fyen and Sjælland to Copenhagen. From Copenhagen a ferry service carries the traffic on to Sweden. The other main line comes from North Germany (Russian Zone) via Warnemünde by ferry to Gedser (Falster) and from there to Copenhagen. The latter line is practically out of count just now.

The bottlenecks in international traffic have been the crossings from the continent to the islands and from one island to another, and up till now two bridges have been constructed to deal with the traffic, one from Jutland to Fyen crossing the Little Belt, and one from Falster to Sjælland.

As the next step plans have been discussed for years concerning the construction of bridges across the Great Belt (between Fyen and Sjælland) and across Øresund (the Sound) between Sjælland and the southern part of Sweden. The distances to be bridged are in both cases 16 km (10 miles approx.) as the crow flies.

The project of a bridge across the Sound is especially being discussed at present, and 6 Swedish and Danish engineering firms have combined to elaborate a project of such a bridge. On Tuesday 10th February the director of one of the Danish firms, Civil Engineer Knud Højgaard, gave the following lecture on the subject in the Civil Engineers' Association.

Project for an Øresund connection

Introduction

In the spring of 1936, i.e. 17 years ago, a group of engineering firms published a project embodying a system of Danish motor roads and bridges across the Great Belt and Øresund. The aim was to further the planning of an up-to-date road and rail connection between the Danish islands as well as between Denmark and her neighbors to the North, South, East, and West.

The firms involved were, from Sweden

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and from Denmark

Christiani & Nielsen, Ørstedhus, 41 V. Farimagsgade, Copenhagen V
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In the years following the introduction of the projects they were subjected to a thorough and critical examination by the authorities, and the public in general also received them with considerable interest. At the outbreak of World War II the projects were of course abandoned for the time being, and it is only recently that they were once more taken up for discussion in public. Interest has particularly concentrated on the two extensive bridge projects of the Great Belt and the Sound.

As regards the Great Belt bridge the Danish authorities have taken a special initiative, as a commission has been appointed to investigate the possibilities. Many problems are involved, both of a technical, an economic and a political nature.

While the execution of the Great Belt project may have to be considered mainly as a Danish problem, a connection across the Sound has an entirely different character. This is a task to be undertaken by the Northern countries in cooperation, for although it is primarily Sweden and Denmark which will have to make the decision and bear the expenses of the execution of the work, there is no doubt that Norway and Finland will also be interested in the establishment of a modern continental traffic line.

The task being mainly of interest to Sweden and Denmark, and Sweden being moreover the one of the Northern countries disposing of the greatest resources, it is evident that it will be indispensable for the execution of the project of a Sound connection that Sweden is willing to enter into a cooperation with Denmark as regards the solution of the problem. It is therefore natural to ask how Sweden looks upon the matter. In my opinion the answer must be that, whilst 17 years ago, at its birth, the [redacted] project was received without much enthusiasm in Sweden, the attitude towards it is now much more positive. From the numerous statements published in the Swedish press, both by editors and by the public, it appears that the interest is increasing, and as far as I understand, the Swedish parliament has recently in principle approved of a suggestion that negotiations shall take place between the Swedish and Danish governments in order to find out whether it will be advisable and possible to realize this great project. The matter is placed on the agenda of the meeting of the Northern Council, which is taking place now.

Project of 1936 revised

As already stated, nearly 20 years have passed since the idea of the construction of a bridge across the Sound was first taken into serious consideration, and it is evident that in a renewed discussion of the matter the recent developments within the means of communication will have to be especially considered. In this connection, what is to be considered is not only the fact that traffic both on road and rail, by sea and air has increased on a much larger scale than could be foreseen 20

Years ago another factor of great importance at present is that two of the main lines of communication between the Scandinavian countries and the Continent have practically ceased functioning, namely the line via Warnemünde-Gedser (Germany-Denmark) and that via Sassnitz-Trelleborg (Germany-Sweden).

In reviewing the Sound project of 1936 an important point is that ideas and amendments will to a great extent have to be based on the projects which have been undertaken by the public authorities on both shores of the Sound. These projects, which are being studied both by Danish and Swedish authorities, are proof that the possibility of a connection across the Sound in a near future is taken into account.

As a first step towards an amendment of the plans the 3 Swedish firms revised the project of 1936 in the course of the autumn of 1952 in order to inform the Swedish authorities of the estimated expenses of a bridge today. The calculations show that the construction which before the war might have been built for about DC 150 million (£ 21.5 million), would today cost about DC 550 million (£ 80 million). These figures would cover a bridge with a railway track and a road.

In October 1952 a statement was made to the Swedish authorities and organizations interested, to the effect that a more thorough study would be made of the project, taking the changed conditions into consideration, and this is the result of the study.

Renewed investigations have proved that it would not be advisable to construct a bridge today according to plans which were considered satisfactory 17-18 years ago. Two factors will especially have to be taken into consideration: 1) the fact that the automobile traffic has increased far more than was foreseen, and will develop to an ever increasing extent, and 2) that a connection across the Sound must in no way interfere with the traffic on Kastrup Airport.

In view of the latter point the bridge line across Amager will have to be placed south of the areas which may conceivably be taken over by the Airport, and it is therefore suggested that the new line be placed south of Dragør and of the fortress just outside this town. Moreover, the access to the Airport must be considered, and thus the possibility of constructing an elevated bridge across the Drogden channel is ruled out. Such a bridge would have to be at a height of 50 m (165 ft) above sea level for the greater part of the distance, and the part of the bridge spanning the channel where the ships pass, would have to be about 300 m long (325 yds) and to be 80-90 m (260-295 ft) above sea level. A lower bridge with a bascule span allowing ships to pass, would hardly be adequate in this place, and the only remaining solution will then be to construct a road and rail connection in tunnels below the Drogden channel with approaches on low dams from the shores at Amager and Saltholm.

Across Saltholm and the eastern part of the Sound the projected road and railway can run on dams and along an elevated bridge, as foreseen in the project of 1936. The 3 channels - Saltholmrenden, Flintrenden and Trindelrenden - will then be at right angles on the bridge line, so that the actual passage of the ships will take place in the easiest and safest way. From the point of view of shipping the change from bridge to tunnel at Drogden must be considered a definite improvement; this is the passage mainly used in the traffic [illegible] Sound.

Also for the passage from Amager to Sjælland it might be considered advisable to use a tunnel over part of the distance, particularly in view of the projects for an expansion of Copenhagen Port, which cover the possible construction of a southern port and a deepening of the south channel to 7.5 m (24.5 ft).

With the surface and underground conditions the present project, comprising a bridge-and-tunnel connection, will be rather more expensive than a bridge connection, and everybody will agree that it is more pleasant to go by bridge than to go through a tunnel. We have therefore aimed at shortening the tunnel distances, and I can mention that the length of the tunnels for the road will be abt. 2.3 km (1.5 miles) below Drogden and abt. 1.2 km (3/4 mile) below the south channel between Sjælland and Amager. For the railroad the tunnels will be considerably longer, i.e. abt. 5.5 km (3.5 miles) below Drogden and abt. 3.5 km (2.2 miles) below the south channel, due to the fact that the rise for the railway must be considerably less than that of the road. We have calculated with an admissible rise of 1:100 for the railway and of 3:100 for the road.

In spite of the additional expenses of this construction and of certain, not really important, disadvantages of the traffic in tunnels, the proposed combination of bridge and tunnel must be considered the right solution when all relevant factors are taken into account.

I shall below indicate the alterations in the project made in view of the highly increased traffic between Sweden and Denmark. Some figures will show the development. The number of cars ferried across the Sound was

1935	30.000
1939	41.000
1951	160.000
1952	190.000

It is of interest to state that practically all automobiles use the Elsinore-Hälsingborg crossing; only abt. 12.000 a year have used the Copenhagen-Malmö crossing in 1951 and 1952. This probably implies that the route is used to capacity.

The number of persons using the traffic means between Sweden and Denmark were

1935	1.3 million
1939	1.5 million
1951	3.6 million
1952	5.2 million

The quantities of merchandise transported have increased from abt. 300.000 metric tons a year in the time before the war, to abt. 800.000 metric tons a year in 1951 and 1952.

If a road and rail connection is established between Sweden and Denmark, there is no doubt that the traffic as a whole, and especially the automobile traffic, will increase considerably. I shall later on make a prognosis, but here I shall just underline the fact that a construction like this ought to be built with a view to long-time developments. The large road bridges which were built 15-20 years ago - especially those of the Little Belt and at Masnedø-Orehoved - would probably

have been provided with wider roadways if at the time it had been realised that the increase in traffic would be so rapid and so important as has been the case.

In 1936 it was thought sufficient that the road bridge should carry three roadways. Today we are of opinion that four roadways - two in each direction - will be indispensable both from the point of view of capacity and for security reasons, and we propose that these roadways, both in tunnel and on bridge, have a width of 3 m (9.8 ft), whereas the width on the dams and across Amager will be of 3.5 m (11.4 ft) as is generally demanded for the construction of motor roads. The total width will thus be 2 x 6 m and 2 x 7 m. On the bridge and in the tunnels a stone edging will separate the two directions, and on the dams and on land a stripe of grass will occupy the center of the road.

As regards the railway, after discussing the problem with the Danish State Railway technicians, we have considered it advisable to propose a single track on the bridge and in the tunnels, whereas a double track will be constructed over all land distances and a side track system on Saltholm.

In the original project a track was included for cyclists. In the modified project this has been removed. For one thing cycling in the tunnels will be uncomfortable, and for another the enlargement of the tunnels necessary to make room for a bicycle track will be extremely costly. Finally, it is not likely that there will be much bicycle traffic between Copenhagen and Malmö on account of the long and hilly road. Cyclists who will wish to cross the Sound will therefore have to use train or bus. Motorcycles and bicycles with subsidiary motors may of course use the roadways.

A special problem in connection with the projecting of a link between Denmark and Sweden is that of joining it up with the already existing road and railway systems. In the modified project a tie-up has tentatively been made, but it is evident that many problems in this respect demand a more thorough investigation than it has been possible to make until now. One difficulty to be pointed out is that of tying up the new connection from Sweden with the existing railway system at the Copenhagen Central Station, but it is to be hoped that it will be overcome.

Construction period

As regards the time to be used for the construction of the bridge and tunnel connection described, it should be possible to perform the work in the course of 8 years from the day when the decision has been made; in these 8 years a period is included for a detailed planning of the various construction works. The question is, how much time will it take before a decision can be made. It may be optimistic to count upon 2-3 years. It will depend on the will to reach a rapid solution of the problem on both sides of the Sound.

Construction and maintenance costs

The construction of the combined road and railway connection across the Sound, according to the plan proposed in 1936, would at the level of prices of the time cost abt. DC 150 million. Converted on the basis of today's prices the same bridge would cost abt. DC 550 million.

The revised project now submitted is considerably more costl, which is due to the factors already mentioned: by the shifting of line to the south it has become rather longer; tunnels are used in so... places instead of a bridge, and four roadways are proposed instead of three. In a provisory and approximate estimate the total construction costs will amount to DC 800 million (£ 115 million). To this must be added the fact that at any rate on part of the capital invested interest will have to be paid, and the total sum will thus be DC 1 billion (£ 143 million).

It may be thought that this amount is so enormous that the project will have to be given up. However, it may be possible to obtain the sum in the course of 10 years or so. In this connection it may be mentioned that the Swedish State budget is of SC 8 billion (1.5 billion £) a year, and the Danish of DC 5 billion (£ 700 million).

Moreover, as far as Denmark is concerned, it may be mentioned that billions have already been spent on road constructions and road repairs, and that a yearly sum of abt. DC 200 million (£ 30 million) is levied in the form of various taxes. The road fund disposes at present of DC 600 million (£ 90 million), of which part will be used for the projected road construction.

A distribution of the capital investment between Denmark and Sweden with 50% to each and a distribution of the amount over a period of 10 years would imply a yearly amount of DC 50 million (£ 7 million), and this seems within the limits of possibility. It might be considered whether half the construction costs could be a direct state subsidy (through the road fund or other means), corresponding to DC 25 million a year for 10 years from each side of the Sound, while the second half might be obtained by issuing government bonds for which interests and depreciation might be covered by the bridge revenue.

This raises the interesting question whether a road and railway connection like the one proposed, can and ought to yield revenue. Even with bridge or road connections of some importance in this country, we are no longer accustomed to paying turnpike money. The development in the USA has gone in the opposite direction. The payment of passage money is considered a matter of course, and the actual payment is easily arranged. From detailed statistics it appears that the revenue everywhere exceeds by far that foreseen in the financial forecasts.

An operating budget for a Sound connection would be pure conjecture, but a hypothetical budget for the traffic which might be reached 5 years after the connection has been established, i.e. at the earliest 15 years from today, would be along the following lines:

The yearly revenue:

Passenger cars	2 million à DC 10.00	DC 20 million
Motorcycles	1 million à DC 4.00	DC 4 million
Buses, 2 million passengers à DC 2.00		DC ½ million
Trucks, 100.000 vehicles à DC 20.00		DC 2 million
Contribution of railways		DC 3 million
	Total:	DC 33 million

The operating and maintenance expenses for tunnels and bridges may be estimated at 3 or 4 million a year.

On this basis an amount of abt. DC 30 million would remain for interests and reimbursement of DC 500 million (half of the capital invested, as mentioned before).

As regards the single items of the revenue, it may be said that a payment of DC 10.00 per passenger car is high, but it is to be considered that no special payment has to be made for the passengers, and if they number 3 per car, this means that not only 2 million cars but also 6 million persons can go from Sweden to Denmark and vice versa by paying DC 20 million, and that may certainly be considered reasonable.

Whether the rail traffic will be able to contribute 3 millions it has not been possible to find out. The figure may be 2 or 3 times higher, or this item may be excluded if, for example, the connection were established as a road connection only. This is a solution which cannot be quite excluded. In that case the construction costs would be reduced by 30 to 35 %, and would only amount to DC 550 million as against DC 800 million for a combined road and rail connection.

Social effects of the project

When the projects of road and railway connections across the Great Belt and the Sound were submitted in 1936, the effect of their adoption on the unemployment problem was strongly underlined. At present both Denmark and Sweden have very nearly 100 % employment, but nevertheless it is thought that the employment possibilities in connection with the constructions will be of interest. The share of the capital used for salaries will be abt. DC 250 million ($ 35.7 million), and in general it may be estimated that a salary outlay of DC 250 million will indirectly create more employment, so that in fact employment corresponding to about double that amount will result.

Moreover, experts are of the opinion that a depression and unemployment cycle is bound to set in, and both in Sweden and Denmark plans are being made to counteract this development. The construction of a connection across the Sound might naturally be included in such plans.

In addition to the other advantages offered by the project, its value from a tourist point of view both for Denmark and for Sweden may also be mentioned.

Prognosis of traffic

Here it will be necessary to mention some figures showing the development in the motor traffic of recent years:

Number of passenger cars, not including motorcycles:

in	1938	1951	Increase %
USA	25.6 mill.	42.6 mill.	66
Sweden	156.000	313.000	100
Belgium	154.000	324.000	110
Switzerland	76.000	170.000	124
Denmark	110.000	122.000	11

On the basis of these figures the prognosis can be made. It is quite apparent that Denmark is far behind as regards the growth in the number of vehicles. When conditions permit it, the number of motor vehicles will be increased by 100 % in the course of a few years. In Norway and Finland an increase may also be expected.

The number of cars available is not the only factor to be considered. Traffic will also depend on the amount of exploitation of each vehicle, and there is no doubt that the degree of exploitation is far higher today than 15 years ago.

The increase in traffic across the Sound in the course of the last 10-15 years has already been given.

A comparison with the development in connection with the bridge across the Little Belt may be of interest. In 1927, when it was decided to build the bridge, abt. 62.000 motor vehicles were ferried across the Little Belt. The year before the opening of the bridge in 1935 the number had increased to 116.000. In the calendar year 1936 533.000 motor vehicles passed the bridge, i.e. 4.5 times as many as immediately before the opening and 9 times as many as in 1927. Since then traffic has developed as follows:

1938	614.000	motor vehicles
1950	785.000	" "
1952	885.000	" "

For the bridge Masnedø-Orehoved the increase in number of motor vehicles the first year after the opening of the bridge was such that 7.5 times as many crossed the bridge as were ferried the last year preceding the opening of the bridge.

Similar instances may be given for great bridges in Sweden.

All things considered, the figures given as a prognosis for a future connection across the Sound may even be too low. They may be 50 or even 100 % higher.

Where to place the connection

This is of the utmost importance. The point is to select a place where the maximum use, i.e. the maximum traffic, may be expected. The traffic will be partly inter-Scandinavian, but partly also international transit traffic.

I would estimate that perhaps 70 or 80 % of the total traffic will be Swedish-Danish, as the connection will, quite naturally, be used mainly by the 2 million Danes and Swedes peopling the shores of the Sound. This factor will probably have to be considered first of all, and it is definitely in favor of the line Copenhagen-Malmö. To this must be added the fact that the geological conditions here are especially favorable both for a tunnel and a bridge: the sea is relatively shallow and the bottom is firm chalk rock where the pillars of the bridge and the tunnel are easily placed. Also from the point of view of shipping the conditions are favorable, especially when tunnel constructions are used, as suggested. Finally it is to be mentioned that excellent road tie-ups are easily established on both shores of the Sound, but that it is a disadvantage that some difficulties will arise when the traffic from Sweden enters the Copenhagen Central Station.

Consequently, the firms involved considered it advisable to concentrate their efforts on a project between Copenhagen and Malmö.

However, there are also other possibilities, and in the course of the years three other lines have been discussed, namely one between Taarbæk on the Danish side and Barsebäk on the Swedish, one across the island of Hven, and one to thernorth of Elsinore-Hälsingborg. The two former lines are not likely to be considered, if only because the constructions will prove far too costly. The line Elsinore-Hälsingborg will offer the shortest and quickest connection between Sweden and Denmark, 5.5 km (3.4 miles), and this is a factor in favor of placing the connection here. For the railways this line would be preferable. But the question is if this traffic is to be considered over and above the motor traffic which more and more, all over the world, takes the place of the railway traffic. Here also the bottom and the current will cause greater difficulties in the construction of a bridge or of a tunnel than for the line Copenhagen-Malmö.

Three projects have been established for a northern connection, two as bridges and one as a tunnel. The estimates seem to indicate that the construction costs for this line will not be very much higher, and for a tunnel perhaps even lower, than for the Copenhagen-Malmö line.

In connection with the decision I wish to point out that in the long run it may not be a question of either-or, but of both-and. A solution would be to establish a motor road connection Copenhagen-Malmö to begin with, and later on a railway connection Elsinore-Hälsingborg, possibly with the use of a tunnel. In that case the railway traffic would have to take place by means of the existing ferry connections Copenhagen-Malmö and Elsinore-Hälsingborg, and anyway it may be advisable to keep these connections as a reserve, allowing people who prefer this means of communication, to go by sea. It is quite likely that in the traffic between Denmark and the other Scandinavian countries all the lines of communication may be used to capacity, including the air lines.

As an illustration of the projects 9 drawings have been made, 4 for the southern line and 5 for a bridge or tunnel connection between Elsinore and Hälsingborg.

No. 305 Projected line of tunnel-bridge connection Copenhagen-Malmö
No. 306 Profiles of railroad and of motor road
No. C 307 Details of tunnels and bridge
No. 308 Details of tunnels and bridge

No. 401 Projected line of bridge connection Elsinore-Hälsingborg
402 Map Elsinore-Hälsingborg and details of bridge
403 Another bridge project Elsinore-Hälsingborg
404 Projected line of tunnel Elsinore-Hälsingborg
405 Details of tunnel Elsinore-Hälsingborg

[not available]